

(12) AUSTRALIAN PATENT ABSTRACT

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(54) MIXING NOZZLES FOR FLUID FLOW

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(74) CO

(57) Claim

1. A mixing nozzle for fluid flows, the nozzle including an inlet and an outlet, said nozzle including between said inlet and said outlet means to cause acoustic pressure fluctuations to cause the fluid jet to give enhanced-mixing with the surrounding environment.

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# COMPLETE SPECIFICATION (ORIGINAL)



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### TO BE COMPLETED BY APPLICANT

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Complete Specification for the invention entitled:

"MIXING NOZZLES FOR FLUID FLOWS"

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The following statement is a full description of this invention, including the best method of performing it known to me.

This invention relates to improvements in mixing nozzles for gaseous flows, such as those employed in combustion chambers or boilers firing gaseous or particulate fuels where it is necessary for a fuel-rich stream 5 of fluid to be mixed as efficiently as possible with an oxidizing fluid. It also pertains to other mixing applications not necessarily involving combustion.

One usual constraint in the design and operation 10 of combustion nozzles is that the mass flow rate of the fuel is limited by the stable combustion limits of the fuel mixture. In general terms, a flame will stand-off from the burner nozzle the distance required for the nozzle jet velocity to decay (through growth and mixing) to the level of the mixture flame propagation velocity. Hence, if the spreading rate and mixing 15 of the fluid jet emanating from the nozzle can be greatly increased, the flame front will be more stable, and will be positioned closer to the nozzle. In a similar manner, improvements in the mixing process for the combustion of particulate fuel such as pulverised coal 20 can lead to more effective control over the particle residence times required for the drying of the fuel, the release of gaseous volatiles, the combustion of the particles, and the control of noxious combustion products.

25 Mixing-promoting methods currently in use often lead to severe pressure loss through the mixing nozzle, and are usually constrained to operate below a critical momentum of the jet of fluid. Devices currently in use include swirl burners, bluff-body expanders and 30 so-called slot-burners, each with its own disadvantage in terms of pressure loss or flame instability at high flow rates.

3.

It is the object of this invention to provide enhanced-mixing between gases without severe pressure loss through the nozzle-jet system.

Thus there is provided according to the invention  
5 a mixing nozzle for fluid flows, said nozzle including  
an inlet and an outlet, said nozzle including between  
said inlet and said outlet means to cause acoustic  
pressure fluctuations to cause the fluid jet to give  
enhanced mixing with the ambient fluid.

10 In order to more fully describe the invention  
reference will now be made to accompanying drawings  
in which Figs. 1 a b c d show four alternative forms  
of the invention with a resonant cavity, Fig.2 shows  
a form utilizing sound waves to apply the pressure  
15 fluctuations, Fig.3 shows a further alternative form,  
Fig.4 shows a still further alternative form and Fig.5  
shows a form utilizing a whistle.

Fig.1 shows schematic outlines for four typical  
implementations of the invention. Figs. 1(a) and 1(b)  
20 are for the mixing of a gaseous stream with ambient  
fluid. The gas to be mixed flows through plane (1)  
shown in each case, and the mixing occurs beyond plane  
(2). Fig. 1(c) is a typical geometry for the mixing  
of two gaseous streams, one inner and the other outer,  
designated by FLOW 1 and FLOW 2 respectively. FLOW 1 may  
25 or may not contain particulate material.

All four constructions shown in Fig.1 consist  
of an axisymmetric cavity of diameter greater than  
the inlet flow section diameter (plane (1)) and a restric-  
30 tion at plane (2). There may or may not be a restriction  
(in the form of an orifice plate or similar) at plane  
(1), and the cavity may or may not be of constant dia-  
meter along its length in the direction of flow.

The operation of the nozzle is that, at design conditions, an acoustic resonance inside the cavity between planes (1) and (2) is fed by the flow instabilities emanating from the sudden expansion at plane (1).

5      The cavity may be designed to have one or more acoustic resonances concurrent at a particular flow rate or over a range of flow rates. The acoustic modes of resonance may be plane-wave or higher order modes, or of the "edge-tone" type. The flow in the core of

10     the cavity may be subsonic, sonic or supersonic where, in the last two cases, only the edge-tone type of acoustic mode will exist.

The cavity is designed to have one or more acoustic resonances at frequencies equal to an integer multiple or sub-multiple of the eddy shedding frequency at plane (1) for the flow rates of interest. The acoustic modes need not necessarily be propagating modes. The acoustic cavity is designed for the particular installation, and it has been found that the cavity is self-tuning for the particular flow rates for that installation, the invention still being effective even though perfect resonance does not occur.

The enhanced-mixing downstream of plane (2) results from the formation of one or more toroidal vortices at plane (2) and there may or may not be a reversed flow region downstream of plane (2), depending on the strength of the acoustic modes in the cavity and their coincidence with the vortex shedding frequency at plane (1).

30     Thus the mixing device of the present invention by incorporating an acoustic resonant cavity associated with the flow through the device so that it has a resonant chamber or cavity opening to the flow promotes mixing and also due to the formation of the eddys or

35     toroidal vortices at plane (2), the flow rapidly

diverges, and slows down to less than the flame front velocity thus presenting a stable condition for a flame.

The devices are preferably circular, but may be of other shapes, such as square, octagonal, elliptical 5 or the like in cross-section. If the section has sharp corners or edges, they may have to be rounded in order to preserve the acoustic effect. As described there may be one or more fluid streams, and any fluid stream may carry particulate matter.

10 The flow can be subsonic or supersonic depending on the particular application, and the acoustic cavity can be such that the flow, or one of the flows, passes through the cavity, or the cavity can be a branch opening into the fluid flow stream, it being realised that 15 the invention is not limited to the use of one cavity only, but a plurality can be utilized either in a line or on side branches. Also acoustic attenuation can be added if desired.

20 As noted above the invention relies on the use of acoustic pressure fluctuations to cause the fluid to give enhanced-mixing, and as described above an acoustic resonant chamber may be employed. Thus in the above examples, the acoustic pressure fluctuations derive their motivation from the fluid flow itself, 25 but in alternative arrangements the disturbances can be caused by other means.

Thus in Fig.2 there is provided in the duct a loudspeaker 3 which may or may not have a horn, in the duct or tube 4. The inlet 5 may be of lesser diameter than the tube 4, or if the same size as tube 4, a 30 pressure reducing member will be provided upstream of the loudspeaker 3 to prevent the pressure fluctuations passing upstream of the loudspeaker 3. The frequency

6.

and intensity of the sound waves emanating from the loudspeaker 3 are tuned to achieve the desired pressure fluctuations for the particular flow rate and the fluid medium.

5        In Fig. 3 the loudspeaker 3 is positioned at one end of the tube 4 with the inlet 5 positioned on one side of the tube.

10      Fig. 4 shows a further embodiment with the loudspeaker 3 being positioned on one side of the tube 4, a pressure reducing medium 6 being between the inlet 7 and the loudspeaker.

15      In Fig. 5 the acoustic pressure fluctuations are formed by a notch 8 forming a whistle or the like, the fluid on passing through the notch 8 or plurality of notches providing the desired pressure fluctuations.

In further embodiments (not shown) the pressure fluctuations could be produced hydraulically, electromagnetically or mechanically by providing, for example in the wall of the tube, a vibrating membrane.

20      In the examples shown in Figs. 2 to 4, the loudspeaker can be controlled to give the desired frequency and/or intensity of sound, and this can be an automatic control which varies in dependence upon the flow of fluid medium through the unit, and for example some  
25      form of feedback control can be provided by sensing the mixing and/or flame front from the burner, desired in combination with means of sensing the flow rate in order to automatically control the loudspeaker to achieve the desired acoustic pressure fluctuations.

The burner can be applied to any fluid, and while it is preferably desirable for use with gaseous fluids and also with for example air carrying with it a combustible solid medium, such as pulverised coal or some other 5 combustible medium, the invention could also be applied to other fluids such as liquids where the burner is designed for burning for example kerosine or fuel oil.

It is to be realised that if liquids are utilized in the invention, that in order to achieve the desired 10 result greater energy would be expended in order to achieve the acoustic effect in the liquids.

While the burner can be constructed of metal, it is to be realised that other materials can be used, either being moulded cast or fabricated, and the burner 15 could for example be formed of a suitable ceramic material.

Although various forms of the invention have been described in some detail it will be realised that the invention is not limited thereto but can include variations and modifications falling within the spirit and 20 scope of the appended claims.

8.

The Claims defining the invention are as follows:

1. A mixing nozzle for fluid flows, the nozzle including an inlet and an outlet, said nozzle including between said inlet and said outlet means to cause acoustic pressure fluctuations to cause the fluid jet to give enhanced-mixing with the surrounding environment.

2. A mixing nozzle as defined in claim 1 wherein said means is either self-tuning or tuned by use of a control system.

3. A mixing nozzle as defined in claim 2 wherein said means is a resonant cavity to give a self-tuning effect.

4. A mixing nozzle as defined in claim 2 wherein said acoustic pressure fluctuations are applied by means driven by an external power source.

5. A mixing nozzle as defined in claim 3 wherein said resonant cavity is formed by an enlargement in the end of a tube through which the fluid flows.

6. A mixing nozzle as defined in claim 3 wherein said resonant cavity is formed by apertured walls dividing a tube through which the fluid flows.

7. A mixing nozzle as defined in claim 3 wherein two flows of fluid are mixed by flowing through a pair of concentric tubes, the outer tube opening into an expanded resonant cavity, the outlet of the cavity being planar with the outlet of the inner tube.

8. A mixing nozzle as defined in claim 4 wherein said means for applying acoustic pressure fluctuations comprises a loudspeaker directed into a tube through which the fluid flows.

9.

9. A mixing nozzle as defined in claim 8 wherein said loudspeaker is situated concentrically in the tube and facing towards the outlet of the tube.

10. A mixing nozzle as defined in claim 8 wherein said loudspeaker is situated in a wall of the tube and facing across the tube.

11. A mixing nozzle as defined in claim 8 wherein said loudspeaker is situated at one end of the tube, the inlet being situated in a wall of the tube between said loudspeaker and the outlet of the tube.

12. A mixing nozzle as defined in claim 1 wherein said means to cause acoustic fluctuations is a whistle positioned in the fluid flow.

13. A mixing nozzle as defined in any preceding claim wherein the fluid is a gas.

14. A mixing nozzle as defined in any preceding claim wherein the fluid is a gas carrying particulate solids.

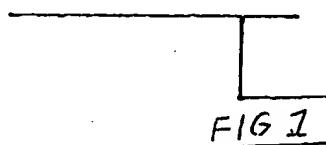
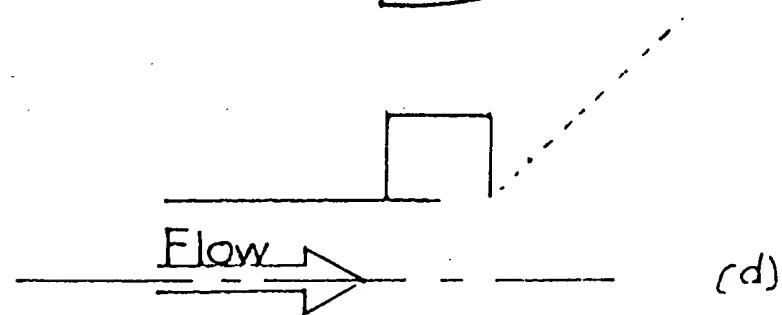
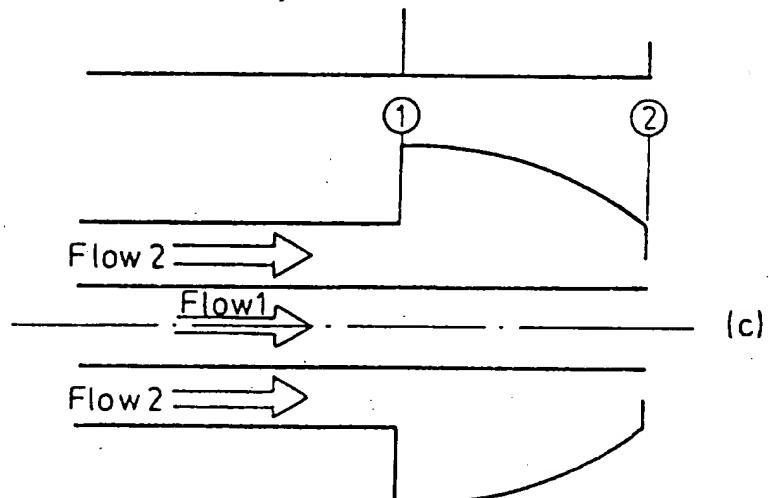
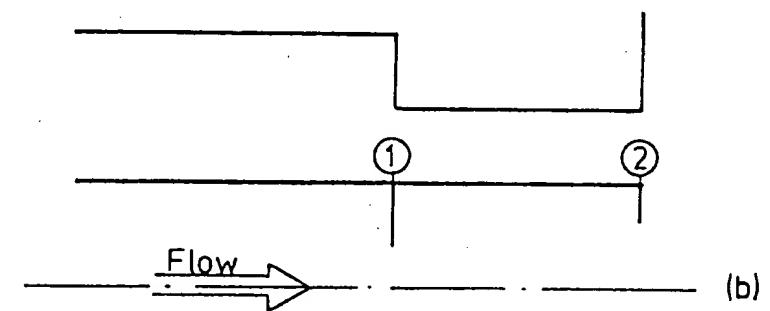
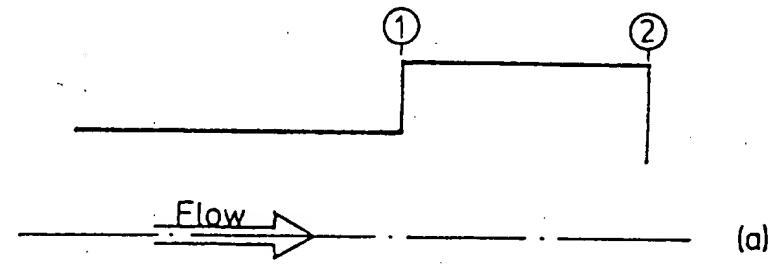
15. A mixing nozzle as defined in any preceding claim wherein the fluid is a liquid.

16. A mixing nozzle substantially hereinbefore described with reference to any one of the accompanying drawings.

Dated this 4th day of October 1982.

CHRISTOPHER JOHN ABELL  
By his Patent Attorneys  
COLLISON & CO.

88 999/82



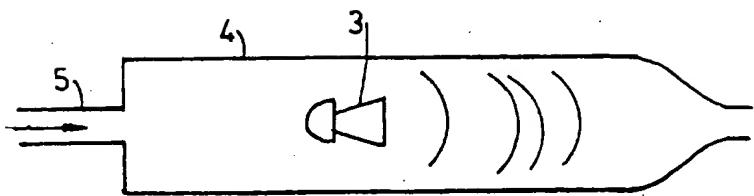


FIG. 2

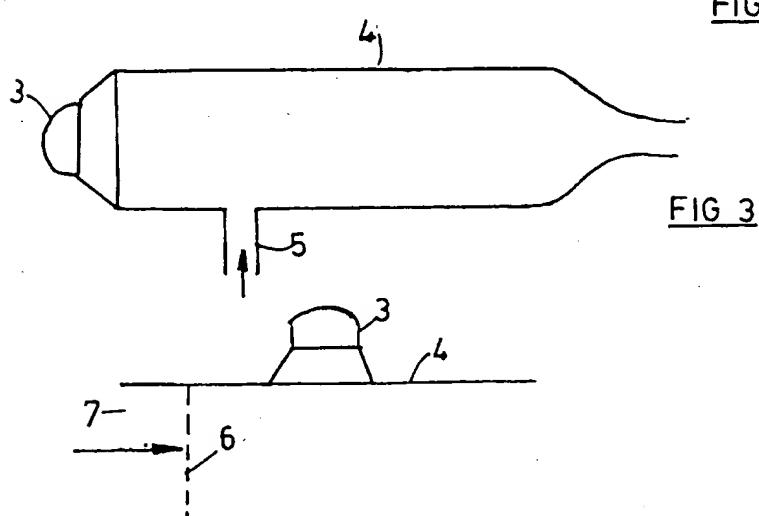


FIG. 3

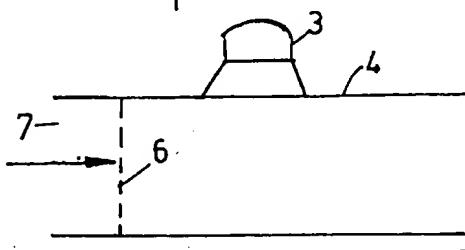


FIG. 4

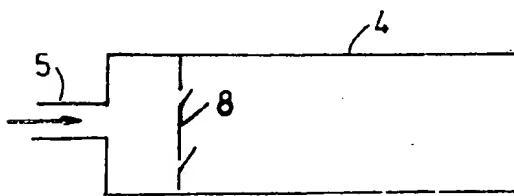


FIG. 5

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